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## 睑板腺功能障碍辅助治疗仪研究

**Research and Implement on adjuvant therapy instrument  
for Meibomian Gland Dysfunction**

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## 摘要

睑板腺功能障碍是蒸发过强型干眼症的主因，在我国有着很高的发病率。本文针对睑板腺功能障碍治疗中的最重要步骤——热敷和睑板腺按摩，进行机电一体化研究，设计并初步实现了一种用于睑板腺功能障碍的辅助治疗仪。

通过对常见辊式按摩的研究，发现了其设计缺陷，并据此提出了一种基于反相半辊滚压原理和包络按摩原理的改进按摩方式。根据人体工效学的要求，以人眼部数据的统计均值作为参考基准，按照所提出的两种按摩原理，分别设计出了符合正常人眼轮廓和结构的按摩机芯和包络扫掠结构。同时设计了一种瞳距调整机构，用以满足治疗仪器对于不同病人的适用性。

以医用级 TPU 为材质，设计和制造出外形可与按摩结构相搭配的气囊层。气囊层能够将仪器与外界隔离，保证了仪器的密封性和稳定性。在结构上，薄膜气囊中被嵌入了碳纤维加热材料，严格保证了眼睑的均匀受热。

治疗仪采用单片机作为控制器。按摩模块由步进电机驱动，可以达到低速高转矩的效果。热敷部分采用柔性碳纤维束作为加热源，利用热电偶对温度进行监测，通过反馈控制的方法保证温度的恒定。在保证仪器气密性的前提下，采用微型气泵对气囊进行充放气，实现气压以及按摩压力的控制。

在热敷、按摩、气压等功能的结构及控制部分的设计工作完成后，根据各部分之间的联系，对治疗仪的进行总体集成设计，并详细叙述了各元件和线路的布局情况。

**关键字：**睑板腺按摩；热敷；气囊；控制；系统集成

## Abstract

Meibomian gland Dysfunction is the main reason of evaporative dry eye which has a high morbidity in our country. This article did research on electromechanical integration for the most important steps in MGD treatment, which consists of compress and Meibomian gland massage, designed an adjuvant treatment instrument for MGD and got a primary implementation.

An extrusion method using anti-phase massage rollers and a theory on envelope plane and a new massage method were proposed after a research on traditional rolling massage whose design limitations were found. According to the ergonomic requirements, the statistical mean of eye data was set to be basis of reference. Massage module and enveloping structure, which conform to the eye outline of normal persons, were designed respectively on the basis of the two massage theory. Meanwhile a pupillary distance adjustment mechanism was designed to meet the adaptability of instrument for different patient.

Airbag layers, whose shape matched massage structure, were designed and manufactured using medical grade TPU. Airbags can separate the instrument from outside world that ensures the leakproofness and stability of the instrument. Structurally, carbon fiber for heating were embedded in film airbags to strictly ensure eyelids to be heated uniformly.

The treatment instrument adopts the single-chip microcomputer as controller. Massage module driven by stepper motors could achieve an effect of low speed and high torque. The hot compress part adopted flexible carbon fiber bundle as the heating source, monitored the temperature by thermocouple and kept the temperature constant through feedback control method. In order to ensure the instrument tightness, a miniature air pump for inflating and deflating the balloon, control of pressure and massage pressure. On the premise that the instrument was sealed, the air pressure and massage pressure were controled when the air pump inflated and deflated the airbags.

After design work of structure and control module, instrument integration design was made and distribution of components and circuits was discussed according to the contact among all parts.

**Key words:**Meibomian gland massage; Compress; Airbag; Control; System integration

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